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Problems of using volcanic thermae of the Kurile-Kamchatka Island arc for Power.

Within the Kurile-Kamchatka zone of present-day volcanicity, as well as in many other volcanic regions, there are great resources of thermal power consisting of high temperature volcanic gases, gas vapour jets and various thermal waters. In active volcanic regions (zones of tectonic crushing), the latter come out to the surface of the earth and create numerous big groups of various thermal springs, and among them geysers — these very striking, though rare natural phenomena. However, natural issues of thermal waters to the surface are, as a rule, only an insignificant part of the immense resources in thermal waters concentrated in volcanic regions, which could be, in many cases, brought to the surface by boring.

Sources of thermal power for all these hydrothermal resources are present magmatic foci. However, great thermal anomalies, observed on the surface of active volcanic areas, are mostly not caused by a heat transfer from magmatic foci directly by the rocks (owing to their thermal conductivity) but are a result of the penetration to the surface or into subsurface horizons of rocks of high-temperature volcanic gases, steam jets and thermal waters.

In such cases, the created powerful thermal flows, directed towards the surface, are connected with great discharge foci for superheated underground pressure waters.

Data, accumulated during recent years on thermal waters of many volcanic areas, permit to form a more complete idea about their composition, the conditions under which they have been originating and their importance for power utilization.

Within the Kurile-Kamchatka volcanic zone, as well as in many other areas of present-day volcanicity (Japan, New Zealand, Iceland

PRINCIPAL GENETIC TYPES OF THERMAL

Principal types of thermae	Formation conditions	Water temperature at point of issue in °C	Typical ion composition	Water mineralization in g/l
I. Sulphurous-carbonated	In the upper oxydizing environment, in a mass of volcanic rocks affected by volcanic gases	up to 100	a) Surficial-sulfate ions of complex cation composition	up to 5.0
			b) Deep-seated chloride-sulfate ions of complex cation composition	up to 20.0
II. Carbonated	In a reducing environment, in a zone affected by thermometamorphic processes, chiefly in closed and half-closed structures	up to 80	Chloride and sulfate-hydrocarbonate, natrium and calcium-natrium	up to 10.0
III Nitric-carbonated	In a reducing environment, in regions intensely affected by the heat of active magmatic foci	over 100	Chloride and carbonate-chloride, natrium	up to 5.0
IV. Nitric	In a reducing environment, beyond any connection with volcanic and thermometamorphic processes, chiefly in volcanic rocks	up to 100	Chloride-sulphate, natrium	up to 1.5

WATERS IN THE KURILE KAMCHATKA ZONE

Gas content in litres per one liter of water	pH	Specific components	Origin of principal gases	Origin of waters
Various, often high (0.1) Usually low (0.1)	1.0-5.5 3.0	H, O, H, O, H, O,, HC H, O,, HBO,	Volcanic (magmatic and thermometamorphic)	Infiltration atmospheric waters, sometimes with insignificant participation of « magmatic » and « rejuvenated » condensation waters
Usually high (1.0)	5.5-6.5	H, O, HBO,	Thermometamorphic (CO,)	Infiltration atmospheric waters, sometimes with participation of altered sea waters
Low (0.1)	7.5-8.5	H, O, HBO,	Aerial (N + dif.g.) and thermometamorphic (CO,)	Infiltration atmospheric waters, sometimes with participation of altered sea waters
Insignificant (0.02)	7.5-9.5	H, O,	Aerial	Infiltration atmospheric waters

etc.) four principal genetic types of thermal waters are distinguished; their comparative characteristics are given on Table 1.

As it may be seen from the table, the main types of thermal waters in volcanic regions substantially differ by the hydrogeological conditions of their formation, by their gas and ion composition and areas of development.

Among all these types of thermal waters of greatest significance as a source of power are nitric-carbonated thermae both by their chemical composition, abundant yield and high heat content. Due to a high content in them of chemically-agressive components and owing to a usually lower heat capacity, sulphurous-carbonated and carbonated thermae can not be used effectively for power.

Nitric thermae have, usually, considerably lesser temperatures and yields.

The most characteristic representatives of nitric-carbonated thermae on Kamchatka are springs in the Geyser valley and the Pauzhetka springs, as well as Goriachi Pliazh (Hot Beach) springs on Kunashir Island (Kurile islands).

By their ion-salt composition these thermae are sodium-chloride springs with a low general mineralization (up to 4.5 g/l), a higher boron content (HBO_2 up to 0.165 g/l) and silicic acid content (H_2SiO_3 to 0.280 g/l) and a low general gas saturation (less than 100 ml/l). (See Table 2).

These waters are formed in abyssal highly reducing environments, under abnormally high geothermal conditions, created by present-day magmatic foci.

In zones of their natural discharge, at a depth of several hundred meters, these waters usually have a temperature considerably above 100°C (up to 200° and more). However, owing to a pressure existing at such a depth, these waters occur there in a liquid state and the conditions of their movement are fully subjected to the fundamental hydrogeological and hydrodynamic laws, characteristic of ordinary pressure waters. The formation of the gaseous-vapour phase in superheated waters begins only in near-surface conditions. In coming out to the surface, such waters create powerful boiling springs and steam-water jets, frequently with a geyser regime of flow, determined by an insufficient inflow of water to the issue fissures and canals.

As result of vapour formation, a considerable drop in the temperature of the waters is taking place in near-surface zones, as well as

a general fall in the thermal regime of rocks, in which these waters are circulating.

Analogues of the mentioned waters of the Kurile-Kamchatka zone are thermae of the Wairakei region in New Zealand, which, as is known, are successfully being studied and during the last ten years used as a source of power. To the same type of thermae belong also the waters of Krisuvik region in Iceland, where during recent years prospecting has been carried by boreholes.

In the Soviet Union, first experimental hydrogeological, geophysical and prospecting borings for power resources were started in [illegible] on the Pauzhetka thermal water.

From the geological point of view, the region of Pauzhetka thermae (southern extremity of Kamchatka) is situated in an area of an old trough subsidence filled with Quaternary tuffs; the central part of this trough was subjected during the Quaternary period to a considerable uplift and formed a big positive structure — the Kambalny mountain range with altitudes exceeding 1000 m. With its southern part is associated the young volcanic activity (Kambalny volcano) in the axial zone of which there are now numerous issues of geysers and vapour jets.

Table 2

CHEMICAL COMPOSITION OF NITRIC-CARBONATED THERMAE ON KAMCHATKA, KURILE ISLANDS AND IN VARIOUS OTHER VOLCANIC REGIONS

Region	Springs	M g/l	Chemical composition of water (in mg-equ. %)	H_2SiO_3 g/l	pH
Kamchatka	Pauzhetka (spring Pulsating)	3.0	$\frac{Cl}{(Na+K)}$	0.211	8.2
	Geyser (geyser Velikan)	2.4	$\frac{Cl}{(Na+K)}$	[illegible]	8.7
[illegible] Isl.	[illegible]	[illegible]	$\frac{Cl}{(Na+K)}$	[illegible]	[illegible]
New Zealand	Wairakei (borehole No. [illegible])	[illegible]	$\frac{Cl}{(Na+K)}$	[illegible]	[illegible]
Iceland	Krisuvik	2.3	$\frac{Cl}{(Na+K)}$	[illegible]	8.1

The chief discharge focus of Pauzhetka thermal waters is situated at the north-western foot of Kambalny range, in the valley of the river Pauzhetka on a small thermal area (300 × 500 m). We find here several big boiling springs with a total yield of 35 l per second and two small geysers. The total outflow of thermal water rising to the surface and into alluvial deposits of the valley is estimated to be 100 l/sec.

The first rotary well, put down from the central part of the thermal area to a depth of 800 m, was bored with the use of clay fluid and a continuous extraction of cores. The initial diameter of the well was 16", the final — 7 ¾". Hydrogeological samplings in the well were done at certain intervals by the method of experimental vapour-water discharges. Definitions of water and vapour expenditures were effected by cyclon separators and a calorimeter. Temperature determinations in the well were done by normal mercury and maximum thermometers, as well as by electric thermometers.

The well revealed a thick mass of Quaternary volcanic tuffs, tuff breccia and tuff conglomerates, dacite lavas and, at a depth of 680 m, a mass of Tertiary sandstones and aleurolites.

Temperature in the well rose from 100° at the Earth's surface to 180-190°C at a depth of 250-300 m. The most rapid rise in temperature was observed up to a depth of 120 m, the geothermic gradient in this interval being 0.5°/m.

The main inflow of thermal waters, with a composition identical to that of natural springs, was obtained in the well from a depth up to 300 m out of dacite tuffs, in which the water circulation is of a fissure character.

The heat content of the vapour-water mixture in the well was 170-190 big cal/kg, as compared with the heat content of the natural Pauzhetka springs of 140-150 big cal/kg.

Boring of the first Pauzhetka well established the presence within the investigated region of thermal waters suitable, by their heat content and chemical composition, for use as a source of power.

Available geological and hydrogeological data on the investigated region, permit to assume, that the flow of Pauzhetka thermal waters to the point of their natural discharge, occurs from the South-East, from Kambalny range. Issues of gas-vapour jets, existing within the range, are, probably, manifestations of the vapour phase of overheated waters circulating at depth.

Further problems to be solved by investigations and prospecting work, which has been started, should include a greater detalization of the geological structure of the region, the establishment of the most water-abundant zones and the determination of possible resources of thermal waters for the construction of an experimental geothermal power plant.

Discussion

V. Vlodavetz signale que les volcanologues russes se sont intéressés aux recherches géothermiques dans le sens le plus large du terme, non seulement en rapport avec le volcanisme mais aussi avec les phénomènes de la chaleur profonde du globe. Il présente le premier tome (le seul imprimé actuellement) des publications d'un congrès qui s'est tenu il y a trois ans sur les problèmes de géothermie et d'utilisation de l'énergie géothermique

BIBLIOGRAPHY

1. Иванов В. В. - Основные стадии гидротермальной деятельности вулканов Камчатки и Курильских островов и связанные с ними типы термальных вод. Журнал Геохимия, № 5, 1956. (Main stages of hydrothermal activity of Kamchatka and Kurile Islands volcanoes and associated types of thermal waters)
2. Пийп В. И. - Термальные ключи Камчатки. АН СССР, СОПС, Серия Камчатская, в. 2, М. - Л., 1937. (Thermal springs of Kamchatka).
3. Ivanov V. V. - *Present-day hydrothermal activity within the Kurile-Kamchatka Island arc and its relation to volcanicity* - Bull. Volcanologique, Série II, Tome XX, Napoli, 1959.